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Standard Test Method for TORQUE STABILITY, WEAR, AND BRINE SENSITIVITY EVALUATION OF BALL JOINT GREASES[1]

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1. Scope

1.1 This test method covers two procedures for evaluating the suitability of greases for use in automotive chassis ball joints.

1.2 The Torque Stability Test provides a measure of the frictional and antiwear properties of greases when subjected to load and prolonged working under oscillating motions in ball joints.

1.3 The Brine Sensitivity Test provides a measure of the ability of the grease to prevent noise from an oscillating ball joint when exposed to contamination by brine.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Notes 1, 2, and 3.

2. Referenced Documents

2.1 *ASTM Standards:*

D 235 Specification for Mineral Spirits (Petroleum Spirits) Hydrocarbon Drycleaning Solvent[2]

D 329 Specification for Acetone[3]

3. Summary of Test Method

3.1 A lubricated automotive ball joint stud and bearing, confined in a fixed housing, is rocked through an arc under prescribed conditions of rocking frequency, rocking amplitude, load and time. Noise, wear, and torque are observed or recorded, or both.

4. Significance and Use

4.1 Both procedures are intended as screening tests to aid in the selection of greases for the lubrication of automotive chassis ball joints. Since both the test components and procedures approximate those typical of current equipment and operation, respectively, test results are considered to provide a measure of grease suitability. Neither procedure, however, is intended as a measure of long-time service under actual conditions of operation.

5. Apparatus

5.1 *Ball Joint Grease Tester*—A mechanical unit[4] for a single ball joint but equipped with components for variable speed and adjustable rocking amplitude is shown in Fig. 1. A tester[5] for two ball joints but with fixed speed and rocking amplitude is shown in Fig. 2. The mechanical unit shown in Fig. 1 consists of the following components:

5.1.1 A power system comprised of an electric motor (*A*) which drives a speed reducer (*B*) through a variable pitch pulley (*C*) and belt arrangement.

5.1.2 An eccentric drive (*D*) driven directly off

[1] This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.G on Lubricating Grease.

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 05.03.

[4] Drawings for a single ball joint mechanical unit are available from Research Laboratories, General Motors Corp., Warren, MI. 48090.

[5] A complete tester with instrumentation for two ball joints is manufactured by O. P. Schuman and Sons, Inc., County Line and Titus Road, Warrington, PA. 18976.

the speed reducer (*B*) is connected to the rocker assembly (*E*).

5.1.3 The ball joint housing (*F*) is fastened in the ball joint holder (*G*). The stud of the ball joint is held securely in the rocker assembly (*E*).

5.1.4 An air-operated load cylinder (*H*), connected to the bottom of the ball joint holder (*G*), is used to apply the desired load to the ball joint (*F*).

5.2 *Rocking Assembly*—Figure 3 shows a cross section view of the rocker assembly (*E*), ball joint (*F*), ball joint holder (*G*), and load cylinder (*H*). The height adjuster (*I*) is used to position the center of oscillation of the ball joint bearing on the center line of the pivot bearings. This position is maintained by lock nut (*J*) and socket head cap screws located in the face of rocker assembly (*E*). Strain gages (*K*) are mounted on the strain members (*L*).

5.3 *Ball Joint Holder*—Figure 4 is a view of the ball joint holder (See *G*, Fig. 1) rotated 90 deg. Construction of this unit, the strain members (*L*), and strain gages (*K*) are more clearly defined here.

5.4 *Ball Joint*—A tension-type automotive ball joint is used.[6] Figure 5 shows the components in order of assembly, and the assembled ball joint.

5.5 *Equipment for Measuring Center of Oscillation of Ball Joint*—Figure 6 shows the equipment, measurements to be made, and calculation for determination of center of oscillation. Not shown is a dial-type gage[7] or a micrometer depth gage[8] required to make the measurements. Measurement is described in Annex A1.

5.6 *Torque-Measuring Equipment*—The torque-measuring equipment attached to each ball joint holder is comprised of the following components:

5.6.1 A strain gage bridge assembly consisting of four strain gages[9] cemented to the strain member struts and wired as shown in Fig. 7.

5.6.2 An oscillograph[10] with a frequency response of 500 Hz will produce torque traces as shown in Fig. 8. Torque calibration equipment and procedure are described in Appendix X1.

6. Reagents

6.1 *Stoddard Solvent* conforming to Specification D 235

NOTE 1: **Warning**—(Combustible. Vapor harmful.

6.2 *Acetone* conforming to Specifcation D 329.

NOTE 2: **Warning**—Extremely flammable. Vapors may cause flash fire.

6.3 *Inhibited 1,1,1-Trichloroethane*

NOTE 3: **Warning**—Harmful if inhaled. High concentration may cause unconsciousness or death. Contact may cause skin irritation and dermatitis. May produce toxic vapors if burned.

7. Procedures: Brine Sensitivity Test and Torque Stability Test

7.1 *Test Conditions*—See Table 1. A new bushing, bearing, housing, seal, and clamp must be used for each test. The stud, cap, and plug should be replaced after ten tests.

7.2 *Preparation of Ball Joint Components:*

7.2.1 Check the ball joint housing for a flush fit with the ring (*M*) (Fig. 3). Do not use housings that do not fit flush with ring surfaces. Burred or rolled edges on the housing flange which prevent a good fit can be removed by filing or grinding.

7.2.2 For the brine sensitivity test, the ball joint housing and bearing are used in the "as received" condition. The ball joint housing and bearing should not be cleaned.

7.2.3 The following cleaning procedure is used for the torque stability test:

7.2.3.1 Wipe the bearing with a dry, lint-free paper or cloth. Do not use solvents as the bearing is sintered and will absorb fluids.

7.2.3.2 Wash the stud, housing, and cap thoroughly with Stoddard solvent (**Warning**—See Note 3) or equivalent.

7.2.3.3 With a wire brush or similar device, remove all dirt and scale from the housing exterior.

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[6] Formerly available as Ball Joint Kit No. 7811044 from Saginaw Stearing Gear Div., General Motors Corp., Saginaw, MI. 48605. A new test joint is under development by ASTM.

[7] A suitable dial gage is Model C81Q with a 0.500-in. range made by Federal Products Corp., 1144 Eddy St., Providence, R. I., 02901. A height stand is needed to hold the dial gage.

[8] A suitable micrometer depth gage with a 0 to 3 in. range is No. 445 B-3RL from the L. S. Starrett Co., Athol, MA. Also, a height stand is required to hold the depth gage.

[9] Suitable strain gages are Part No. DLB-A12-2A-S6 available from BLH Electronics, a Division of Baldwin-Lima-Hamilton Corp., Waltham, MA. 02154.

[10] A suitable oscillograph is available from Century Electronics and Instruments, Inc., 6540 East Apache St., Tulsa, OK 74115. Model 460 with a 4-channel magnet assembly, a No. 210053-1 galvanometer, a No. 200A12 dummy plug, and a No. 565B signal conditioning and amplifier module for each torque trace to be recorded.

7.2.3.4 Clean the interior of the housing by presoaking in acetone (**Warning**—See Note 2) and then scrubbing thoroughly with 2/0 steel wool and acetone. Rinse in acetone.

7.2.3.5 Wash the housing again thoroughly with inhibited 1,1,1-trichloroethane (**Warning**—See Note 3). May cause irritation. Dry, and weigh to the nearest 0.001 g (Note 4). Repeat this operation until weighings differ by no more than 0.001 g.

NOTE 4—Cleaning can be facilitated by using an ultrasonic bath of inhibited 1,1,1-trichloroethane.

7.3 *Assembly, Steps Common to Both Tests (Refer to Fig. 5, Ball Joint Components):*

7.3.1 Locate center of oscillation of the ball joint housing as described in Annex A1.

7.3.2 Assemble the stud, bushing, and bearing in the order shown in Fig. 5.

7.3.3 Install the housing in ring (*M*). Install the seal and clamp using Keystone pliers.[11]

7.3.4 Distribute about 4.5 g of the grease to be tested in the housing.

7.3.5 Insert the stud-bushing-bearing assembly in the housing.

7.3.6 Distribute the remainder of the grease to be tested in the bottom cavity of the assembly.

7.3.7 Insert the cap and hold in place with an O-ring.[12]

7.3.8 Fasten the ball joint in the ball joint holder and rocker assembly as shown in Fig. 3. See A1.2.

7.3.9 Adjust the center of oscillation as described in A1.2.

7.3.10 Adjust rocking amplitude and frequency as described in Appendix X2.

7.4 *Brine Sensitivity Test:*

7.4.1 Assemble and position a ball joint, packed with the test grease as described in 7.3. The ball joint housing should not be cleaned before assembly.

7.4.2 Start drive motor and record an initial torque trace of 2 s duration. Continue oscillation for 2 h and make torque traces of 2 s duration after 1 and 2 h.

7.4.3 Stop the drive motor. Insert a hypodermic needle through the seal to vent internal pressure. Without removing this vent needle, inject 5 cm^3 of brine (5 % NaCl in distilled water) through the seal by means of another hypodermic syringe and needle. Remove both needles.

7.4.4 Start the drive motor and oscillate for a period of ½ h maximum. If audible noise, "squawk", develops prior to termination of the ½-h period, stop the test.

7.4.5 Record a torque trace of 2 s duration at the start of oscillation after brine injection, and at 5-min intervals. Also, record a torque trace if "squawk" occurs. Examine the torque traces for evidence of stick-slip (see Fig. 8).

7.5 *Torque Stability Test:*

7.5.1 Prepare a ball joint (see 5.2), pack with the test grease, assemble, and position as described in 5.3.

7.5.2 Start the drive motor. Record an initial torque trace of 2 s duration.

7.5.3 Run for ½ h. Stop the drive motor and reset the center of oscillation if necessary to the predetermined figure (see A1.2).

7.5.4 Restart the drive motor and run continuously for 65 h. Record torque traces of 2-s duration every 2 h.

7.5.5 Stop the test at 65 h and disassemble the ball joint. Note the condition of the grease, the seal, the bearing, and the housing (Note 5). Clean and dry the housing to constant weight. Weigh the housing to the nearest 0.001 g.

NOTE 5—An experienced operator can make judgments of wear surface condition such as scoring and scuffing.

7.5.6 Calculate the weight loss of the housing and record as wear.

7.5.7 Determine the torque from the periodic torque traces (see X2.3). Plot torque versus time.

8. Calculation and Report

8.1 *Brine Sensitivity Test:*

8.1.1 *"Squawk"*—Report whether audible noise ("squawk") did or did not occur, and at what time, after brine injection.

8.1.2 *Torque*—Record torques measured before and after brine injection. Determine the maximum torque after brine injection. Calculate the difference between the maximum torque after brine addition and the torque measured just prior to brine injection. Report this difference as the increase in torque after brine injection.

8.1.3 *Stick-Slip*—Examine the torque traces

[11] Suitable pliers can be obtained as J-22610, Kent-Moore Corp., 28635 Mound Road, Warren, MI. 48092.

[12] A suitable O-ring is 1⅝ by 2⅜6 in., available as No. 568-326 from Detroit Ball Bearing Co., 115 West Willis, Detroit, MI. 48201.

for evidence of stick-slip. (Do not confuse with the presence of 60 Hz electrical noise—see Fig. 8.) Report whether stick-slip did or did not occur.

8.2 *Torque Stability Test:*

8.2.1 *Wear*—Record the weights of the cleaned housing before and after completion of the test. Calculate the weight loss in milligrams and report as wear. Inspect the housing and note whether there is visual evidence of scoring or galling in the wear areas.

8.2.2 *Torque*—Record the torque measurements and plot torque versus running time. After 10 h running time, report the maximum and minimum torques. Calculate the difference between these maximum and minimum torques and report as the torque range.

8.2.3 *Grease Condition*—Note changes in grease appearance after test. Report occurrence of excessive oil separation, changes in consistency, and deposits on the bearing surface.

9. Precision and Bias[13]

9.1 *Precision*—The precision of this test is not known to have been obtained in accordance with currently accepted guidelines (for example in Committee D-2 Research Report RR:D02-1007, "Manual on Determining Precision Data for ASTM Methods on Petroleum Products and Lubricants").

9.1.1 Replicate testing is essential when using this procedure since appreciable scatter in test results can be expected.

9.2 *Brine Sensitivity Test*—Repeatability and reproducibility may be judged from Table 2.

9.3 *Torque Stability Test:*

9.3.1 Wear, maximum torque, and change in torque data generally show appreciable scatter and follow Weibull distributions rather than normal distributions. The usual statistical parameters, such as repeatability and reproducibility, are therefore not appropriate. Weibull parameters such as slope, L_{10}, L_{50}, and $L_{characteristic}$ better describe the distribution of test data.

9.3.2 Precision may be judged from Fig. 9, 10, 11; Weibull plots which report wear, maximum torque and change in torque data from replicate tests of three greases by eight cooperating laboratories. Weibull parameters calculated from these data are summarized in Table 3 (90 % confidence limits are shown in parentheses). Precision may also be judged from the mean and the range for the center 50 % of the test results reported, also summarized in Table 3.

9.4 *Bias*—The procedure for measuring torque stability, wear, and brine sensitivity of ball joint greases has no bias because the value of torque stability, wear and brine sensitivity can be defined only in terms of a test method.

[13] Data were developed with the now discontinued Saginaw joint. New data will be established with the joint now under development.

TABLE 1 Test Conditions

	Brine Sensitivity	Torque Stability
Ball joint housing cleaned before test	no	yes
Grease sample, g	13.5	13.5
Rocking frequency, cpm	150	150
Rocking amplitude, deg	±12	±12
Load, N (lbf)	5780 (1300)	5780 (1300)
Break-in period, h	2	none
Test period, h	½ max	65
Brine added at end of break-in period, cm^3	5	none

TABLE 2 Brine Sensitivity Test Results

Eight laboratories tested two grease samples in replicate tests. Results were:

	Grease G-III-69	Grease G-III-70
Squawk:		
Number of laboratories reporting squawk results	8	8
Number of laboratories reporting squawk occurred in at least Y % of their tests:		
Y = 25 %	8	4
Y = 50 %	6	4
Y = 75 %	6	2
Y = 100 %	3	1
Stick-Slip:		
Number of laboratories reporting stick-slip	7	6
Number of laboratories reporting stick-slip occurred in at least Y % of their tests:		
Y = 25 %	7	5
Y = 50 %	7	4
Y = 75 %	7	3
Y = 100 %	3	2

TABLE 3 Torque Stability and Wear Test Results

	Grease G-III-71	Grease-G-III-72	Grease G-III-73
Wear, mg:			
Number of laboratories	7	7	7
Number of results	28	27	26
Weibull Parameters:			
Slope	1.64	1.69	1.64
	(1.25 to 2.08)	(1.28 to 2.15)	(1.24 to 2.10)
L_{10}	2.20	14.4	13.0
	(1.29 to 3.25)	(8.49 to 21.2)	(7.42 to 19.5)
L_{50}	6.97	44.1	41.1
L_c	8.72	54.8	51.5
	(7.07 to 10.7)	(44.5 to 67.0)	(41.4 to 63.6)
Mean	8.7	50.3	41.5
Range of Center 50 % Results	4.6 to 10.0	27.0 to 55.5	27.0 to 61.1
Maximum Torque, lbf·in.[A]:			
Number of laboratories	8	8	8
Number of results	34	34	27
Weibull Parameters:			
Slope	4.59	5.48	7.43
	(3.54 to 5.67)	(4.23 to 6.89)	(5.65 to 9.47)
L_{10}	64.4	91.9	121.6
	(53.7 to 73.8)	(78.9 to 102.8)	(107.8 to 132.7)
L_{50}	97.3	129.7	156.7
L_c	105.4	138.7	164.7
	(98.1 to 113.1)	(130.6 to 147.1)	(157.1 to 172.4)
Mean	96	128	155
Range of Center 50 % Results	82 to 110	115 to 141	141 to 170
Change in Torque, lbf·in.[A]:			
Number of laboratories	8	8	8
Number of results	33	30	27
Weibull Parameters:			
Slope	1.26	2.32	1.36
	(0.98 to 1.59)	(1.79 to 2.91)	(1.04 to 1.74)
L_{10}	1.49	8.95	8.73
	(0.78 to 2.42)	(6.25 to 11.7)	(4.53 to 14.1)
L_{50}	6.60	20.2	34.9
L_c	8.84	23.7	45.7
	(6.80 to 11.4)	(20.5 to 27.2)	(35.3 to 58.6)
Mean	7.8	20.9	35.4
Range of Center 50 % Results	4 to 10	14 to 24	17 to 58

[A] To convert lbf·in. to N·m, a conversion factor of 0.1130 should be used.

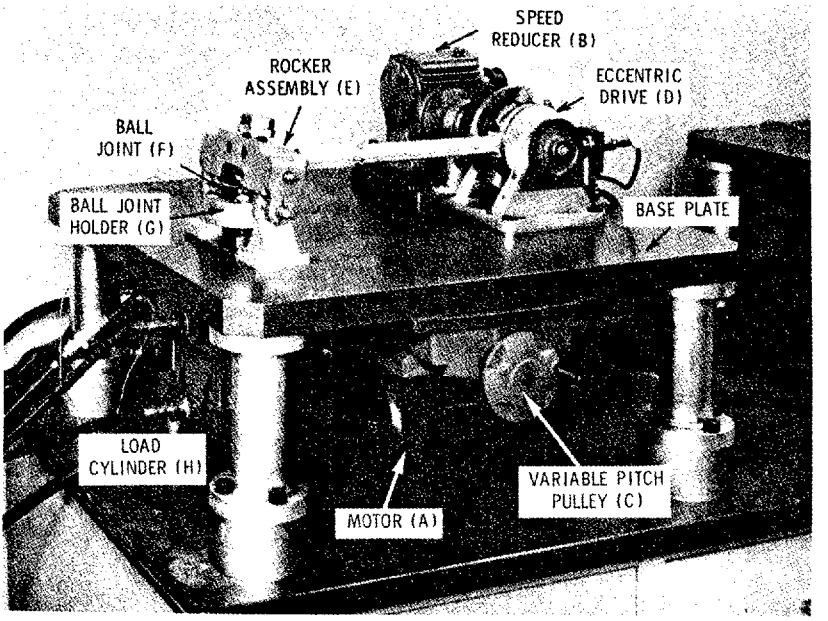

FIG. 1 Ball Joint Grease Tester (One Test Joint)